PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Helical Conveyor Heat-Exchanger

We, METALLGESELLSCHAFT AKTIENGESELLSCHAFT, of 14, Reuterweg, Frankfurt-on-the-Main, Germany, a body corporate organised under the Laws of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to helical conveyor heat-exchangers for flowable substances, including granular, pasty or liquid substances, which conveyors comprise an elongated container, such as a tube or trough, which defines a path of conveyance, and contains helical conveyor means.

In previously proposed conveyors of this kind, a plurality of such helical conveyor elements provided with one or more helices are arranged in parallel and arranged to rotate in the same or opposite senses of rotation. The helices may interengage for a distance which is as large as the depth of the helix or only a part of said depth. Such apparatus may be used as conveyors and also as mixers and kneaders.

It has also been proposed to design such an apparatus as a heat-exchanger by providing a jacket around the housing and/or by using hollow helical conveyor elements so that a heating or cooling liquid or vapour can be conducted through these cavities. These conveyors may then be used as continuous preheaters, driers or coolers.

In conveyors having a helical conveyor element, the material being conveyed is fed between the helical conveyor element and the housing, which closely surrounds said element. During a treatment of pasty or pulpy substances, the helices tend to become filled with such substances so that the element assumes eventually a cylindrical shape. The feeding of the material is then interrupted and the desired effects of a uniform heating, drying, cooling or mixing are not obtained.

In conveyors which comprise a plurality of helical conveyor elements which have helices that extend one into the other for part of their depth, the material is also fed between adjacent helical conveyor elements.

In these arrangements, at least one pair of adjacent helical conveyor elements is arranged so that the helices of both elements extend one into the other throughout the depth of the helices. In this case, the material being conveyed is fed between the housing wall and the helical conveyor elements whereas the material which has accumulated in the helical grooves is forced out of the same in the region where the helices extend one into the other.

If the profiles of the helices are suitably designed, such devices may act as self-stripping conveyors, in which the helical conveyor elements have the same sense of rotation so that the accumulated material can be displaced from the region where the helices extend one into the other. These devices cannot draw material into said region.

When such devices are used for treating viscous pasty material, e.g. for drying such material, the latter tends to form bridges, lumps and clods. This causes a by-passing at least of part of the material over the helical conveyor elements in the space between said elements and the housing cover from the inlet end to the outlet end. Such by-passed material fails to contact the heat exchanger surfaces in a constant state of agitation. It is known that conveyors including pairs of helical conveyor elements which rotate in opposite senses and draw the material into the helices cannot be designed for a self-stripping action with helices that extend one into the other for their entire depth.

In conveyors which automatically draw the material into the helices, the free space be-

[*Price*

tween the helices is filled with the material to be treated. This accumulated material is not revolved and mixed, but overheated or overdried so that the treated material is non-homogeneous. Besides, the heat transfer surfaces are not sufficiently utilized.

According to the present invention there is provided a helical conveyor heat-exchanger, which comprises at least two pairs of hollow helical conveyor elements, the axes of all said helical conveyor elements extending parallel to each other, each said pair consisting of helical conveyor elements having helices of the same hand, the helices of each pair of helical conveyor elements extending one into the other throughout their depth, the helices of one pair of helical conveyor elements having opposite hand to the, or an, adjacent pair, the helices of two of said helical conveyor elements, which respectively belong to different ones of said pairs, extending one into the other only for part of their depth, drive means for rotating the helical conveyor elements of one of said pairs in one direction and for rotating the helical conveyor elements of the other of said pairs in the opposite direction, and a housing having an inner peripheral wall which conforms substantially to a portion of the periphery of each of said helical conveyor elements, and an outer peripheral wall defining a jacket space with said inner wall, said housing being provided with inlet and outlet means communicating with said jacket space for passing a heat transfer fluid through the same, each of said helical conveyor elements being provided with inlet and outlet means communicating with the interior of said helical conveyor elements for passing a heat transfer fluid through the same.

The helical conveyor elements may be arranged so that the parallel axes of said elements lie in one plane, or the axes of different pairs of said elements lie in different planes. In the latter case, in an arrangement comprising four helical conveyor elements, the two inner helical conveyor elements lie in a plane and rotate in opposite directions.

The axes of the two helical conveyor elements which rotate in the same direction are as near to each other as possible so that the helices extend one into the other throughout their depth. The spacing of the axes of the intermediate helical conveyor elements is larger than this minimum because their helices extend one into the other only for part of their depth.

Alternatively, the helical conveyor elements rotating in the same direction may be arranged to lie one above the other with a spacing which is as small as possible. In this case the axes of two adjacent pairs of helical conveyor elements may lie at the corners of a rectangle or parallelogram having short sides which correspond to a minimum spacing between the axes of the helical conveyor elements rotating in the same sense, and long sides which correspond to a larger spacing between the axes of the mutually adjacent helical conveyor elements which rotate in opposite directions. In this case, four helical conveyor elements include one pair of such elements which rotate in the same direction and one pair of elements which rotate in the opposite direction.

The present apparatus combines the advantages of the automatically drawing double-screw systems and of the self-cleaning double-screw systems and for this reason is particularly suitable for treating substances which have a pastelike, viscous or adhesive consistency, for instance for heating or cooling, partial drying, mixing with other substances of the same or similar consistency or with liquids or particulate solids. The apparatus may be used, e.g., for drying azo dyestuffs or terephthalic acid, or for the treatment of clay, such as kaolin, to reduce the water content and admixing dry clay or fireclay particles, or mixing clay with water, or for treating alkalicellulose, fats, soap compositions and the like.

In order to enable the invention to be more readily understood, reference will now be made to the accompanying drawings, which illustrate diagrammatically and by way of example, two embodiments thereof, and in which

Figure 1 is a radial sectional view of the first embodiment showing two pairs of screws, which pairs are arranged to rotate in opposite directions,

Figure 2 is a top plan view showing the two pairs of screws within a housing,

Figure 3 is a vertical transverse sectional view showing the configuration of the housing, which conforms to the profile of the screw array, and the main direction of the flow of material,

Figure 4 is a radial sectional view of the second embodiment showing another arrangement of two pairs of screws,

Figure 5 is a vertical transverse sectional view showing the configuration of the housing associated with the screws of Figure 4, and the main direction of flow of the material, and

Figure 6 is a longitudinal sectional view showing a screw.

Referring now to Figures 1 to 3, there is shown a helical conveyor heat-exchanger comprising pairs of screws 1 and 2, and 3 and 4 each of the screws having the same core diameter *a* and the same crest diameter *b*. The screws 1 and 2 constitute one pair of screws and screws 3 and 4 constitute another pair of screws. The screw axes of each pair of screws are spaced apart by a distance *c*, which is the minimum distance permitting the screw threads to extend one into the other

for their entire depth, as is apparent from Figure 2. The screws of each pair are arranged to rotate in the same direction, which is opposite to that of the screws of the other pair, the screws of one pair of screws having different directions of rotation and different hands from those of the adjacent pair of screws. For instance, with reference to Figures 1 to 2, the pair of screws 1 and 2 have left-hand screw threads and rotate in the clockwise sense in Figure 1, whereas the pair of screws 3 and 4 have right-hand screw threads and rotate in the counterclockwise sense in Figure 1. In Figures 1 and 2, the two pairs of screws are arranged so that all screw axes lie in one plane and are parallel. The distance *d* between the two inner screws 2 and 3 is selected so that the two screw threads extend one into the other only for part of their depth. This spacing *d* of the axis is larger than the minimum spacing *c* but smaller than the crest diameter *b* of the screws. In this arrangement, the two screws 2 and 3 are adjacent to each other and are arranged to rotate in opposite directions, the screws being thus capable of drawing in and conveying the material which is charged to them. During each revolution, each of the screws 2 and 3 is cleaned of adhering material by the adjacent outer screw 1 or 4.

As shown in Figure 2, each of the screws 2 and 3 has only a single thread and each of the screws 1 and 4 has a double thread. Alternatively, the screws 2 and 3 may be double-threaded and the other screws single-threaded. Depending on the circumstances, all the screws may be single-threaded or all may be multi-threaded.

Figure 2 also shows the arrangement of the screws within a trough 5 having an inner wall 6 extending along each side thereof so that the trough 5 is double-walled. The outer wall of the trough 5 and the inner wall 6 define a jacket space, through which may be passed a heating or cooling liquid or vapour, which is supplied to and withdrawn from the jacket space by connection pipes 7. The shafts of the screws 1, 2, 3 and 4 are mounted in bearings 8 and are driven on one side by a single drive means or a plurality of drive means (not shown). It is preferable to use an electric motor, which drives all four shafts through a toothed gear transmission, which comprises directly meshing gears coupled to screws that are to be rotated in mutually opposite directions and idlers meshing with gears coupled to screws that are to be rotated in the same direction. Such transmissions are known and are only one example of a large number of means that are available to a person skilled in the art for rotating the screws in the desired directions.

In the operation of the apparatus, the material to be treated is fed into the apparatus at one end, desirably from above, the main direction of flow of the material being apparent from Figure 3, showing a transverse sectional view, and also showing that the inner wall 6 is shaped to conform to the profile of the screws. In this cross-sectional view of the apparatus, the material being treated is moved around the two pairs of screws in a double loop, the direction of revolution being reversed at the transition from one convolution to the other following the direction of rotation of the respective pair of rotating screws. This movement is superimposed upon the feed movement taking place in the axial direction of the shafts. Partial streams of the material may perform several revolutions about a pair of screws before they enter the loop path around both pairs of screws. These partial streams are small and may be neglected compared to the pass which is being revolved in the main direction. The material being treated is caused by the screws to move to the other end of the apparatus, where it is preferably withdrawn through an opening, not shown, which is disposed at the bottom of the trough 5. Flanges 7*a* serve for securing to the housing a cover (not shown).

In the embodiment shown in Figures 4 and 5, the screws of each of pairs of screws 9 and 10, and 11 and 12, are arranged one above the other and rotate in the same sense. As in the previous embodiment, the screws have a core diameter *a* and a crest diameter *b*. The axes of the screws lie at the corners of a rectangle having the sides *c* and *d*, *c* again being the minimum distance between the screws of a pair of screws rotating in the same sense and *d* being the distance between screws rotating in opposite senses, *d* being larger than *c* but smaller than *b*.

The flow of material which is produced by this screw system in the cross-section of a container conforming to the contour of said said system is apparent from Figure 5. The remarks made in connection with Figure 3 apply also to this flow pattern. The material being treated is additionally fed in the direction of the screw axes from the inlet to the outlet in the cavity 13, which is surrounded by the four screws.

It is to be appreciated that more than two pairs of screws may be combined in the manner which has been represented provided that the total number of screws which are employed is an integral multiple of 4. Such combinations may be obtained by a multiplication of the arrangements shown in Figures 3 and/or 5.

As is apparent from Figures 1 and 4, each screw comprises a core tube 14, to which hollow screws threads are secured. The design of a screw is shown in Figure 6, which is a longitudinal sectional view taken through a single-thread screw. This screw comprises the core tube 14, to which the hollow screw thread 15 is secured. One end of the core tube is

closed by a journal 16, which is guided in a bearing 8. The journal has an end portion, which extends beyond this bearing and forms part of the means for driving the screw in the desired direction.

A tube 17 is fitted into the other end of the core tube 14 with the aid of a liner tube 18, a portion 19 of the tube 17 being mounted in a bearing 8. A tube 20 extends through the tube 17 into the interior of the core tube 14. Those ends of the tubes 17 and 20 which are disposed in the interior of the core tube 14 are sealed from each other by a seal 21. The tubes 17 and 20 define an annular space 22, which communicates through a bore 23 with one end of the hollow screw thread 15. The other end of the hollow screw thread communicates through a bore 24 in the tube 14 with the interior of the latter. A heat exchange fluid e.g. a liquid heating or cooling agent may be introduced into the screws through the tube 20 into the interior of the core tube 14 so as to flow through the same to its other end, where it enters through the bore 24 into the hollow screw thread, through which it flows to the other end thereof. From this other end, it flows through the bore 23 into the annular space 22, from which it is discharged out of the apparatus.

Vaporous heating fluids may be passed through the hollow screw in such a manner that condensate which forms in the hollow screw thread is fed to the outlet end of the screw thread. Depending on the direction of the conveyance effected by the screw, the outlet may be constituted by the bore 23 or 24.

WHAT WE CLAIM IS:—

1. A helical conveyor heat-exchanger, which comprises at least two pairs of hollow helical conveyor elements, the axes of all said helical conveyor elements extending parallel to each other, each said pair consisting of helical conveyor elements having helices of the same hand, the helices of each pair of helical conveyor elements extending one into the other throughout their depth, the helices of one pair of helical conveyor elements having opposite hand to the, or an, adjacent pair, the helices of two of said helical conveyor elements, which respectively belong to different ones of said pairs, extending one into the other only for part of their depth, drive means for rotating the helical conveyor elements of one of said pairs in one direction and for rotating the helical conveyor elements of the other of said pairs in the opposite direction, and a housing having an inner peripheral wall which conforms substantially to a portion of the periphery of each of said helical conveyor elements, and an outer peripheral wall defining a jacket space with said inner wall, said housing being provided with inlet and outlet means communicating with said jacket space for passing a heat transfer fluid through the same, each of said helical conveyor elements being provided with inlet and outlet means communicating with the interior of said helical conveyor elements for passing a heat transfer fluid through the same.

2. A helical conveyor heat-exchanger as claimed in claim 1, in which the axes of all said helical conveyor elements lie in the same plane.

3. A helical conveyor heat-exchanger as claimed in claim 1, in which the axes of different pairs of helical conveyor elements are arranged in different planes.

4. A helical conveyor heat-exchanger as claimed in claim 3, in which the axes of two adjacent pairs of helical conveyor elements lie at the corners of an imaginary rectangle having unequal sides.

5. A helical conveyor heat-exchanger as claimed in claim 3, in which the axes of two adjacent pairs of helical conveyor elements lie at the corners of an imaginary parallelogram having unequal sides.

6. A helical conveyor heat-exchanger substantially as hereinbefore described with reference to Figures 1 to 3 and 6, or Figures 4 to 6 of the accompanying drawings.

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1076587 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1

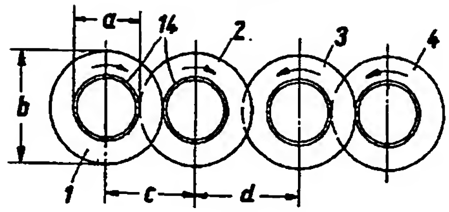


Fig. 2

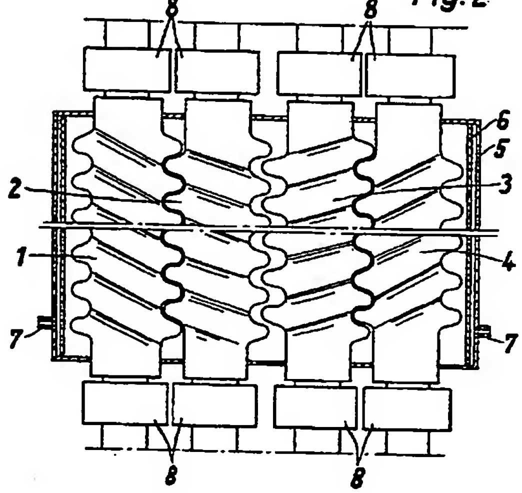


Fig. 3

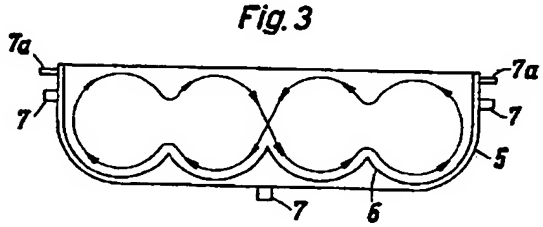


Fig. 4

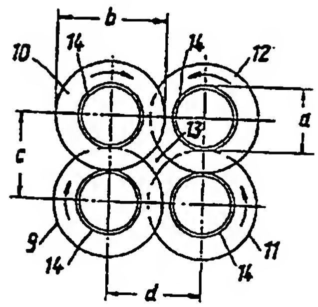
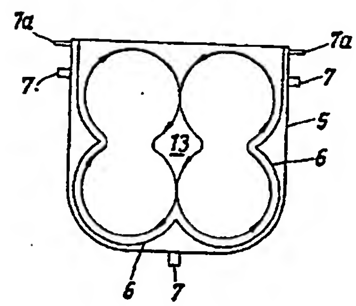


Fig. 5



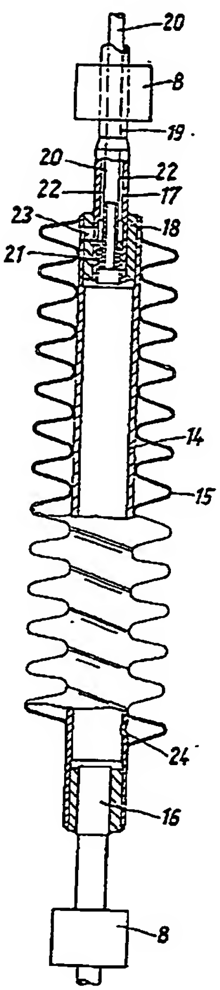


Fig. 6

1076587 COMPLETE SPECIFICATION

3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 2 & 3

Fig. 4

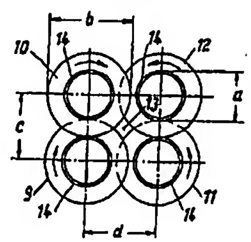


Fig. 5

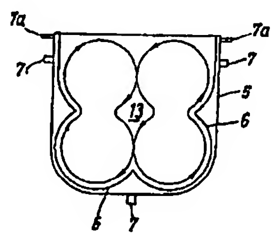


Fig. 6